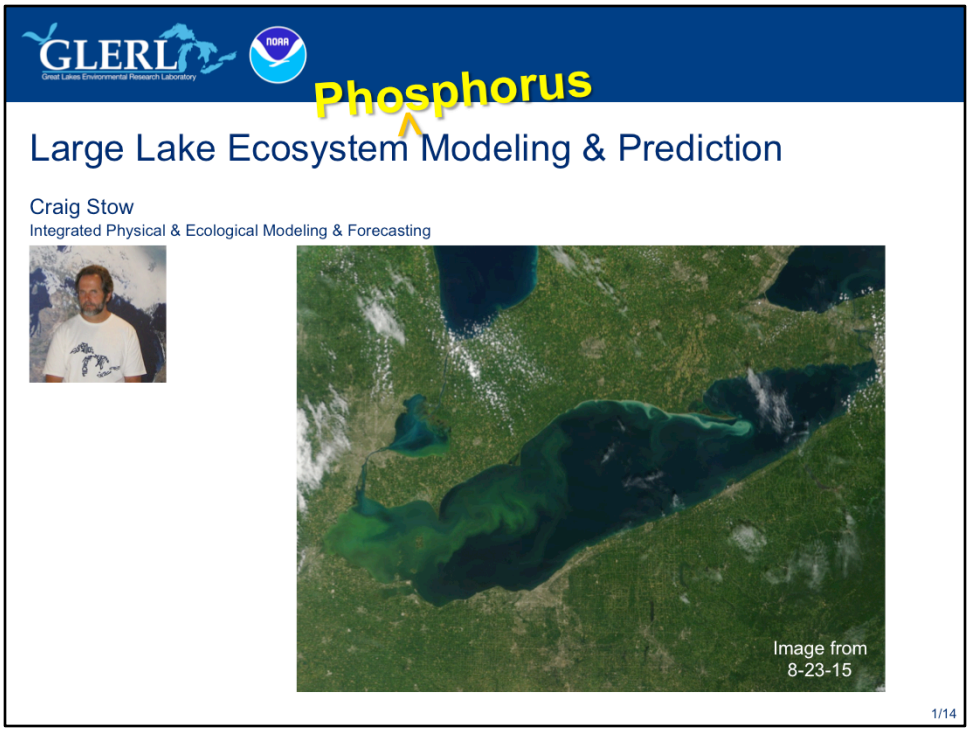


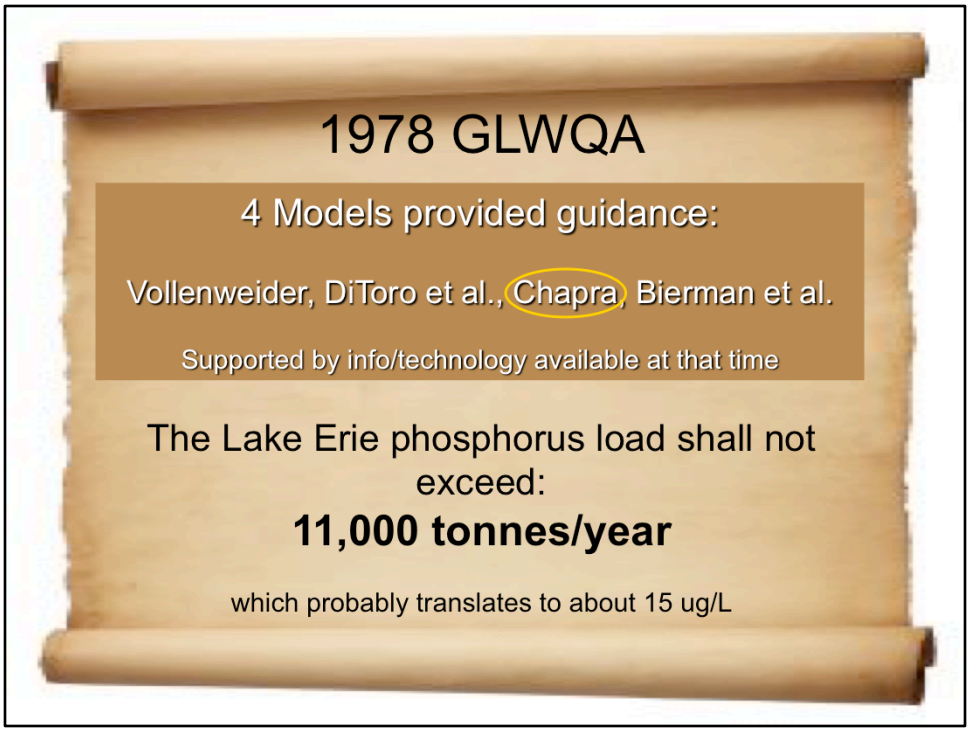
Main topic:
The need for better Phosphorus (P) modeling
Involves interplay of everything we do here
Emphasizes our place in the broader Great Lakes community

As an example:
Groups Craig Stow/GLERL is involved in:
Lake Huron panel last fall
Hosted Cladaphora workshops Great Lakes Water Quality Agreement (GLWQA) ANNEX 4 at GLERL

Working on Lake Erie (done more or less), Moving forward to Lake Ontario, will circle back to Lake Huron and Saginaw Bay again

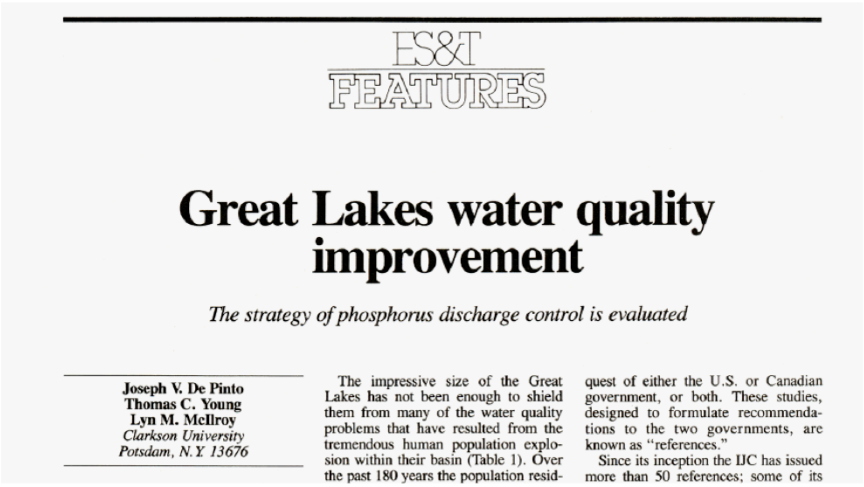
Recent data on Saginaw Bay:
Saginaw Bay isn't meeting P targets
1978 targets
When the dreissenid mussels invaded Saginaw Bay the P retention capacity went up. Mussel filtering results in more P retention in Saginaw Bay, P not circulating out to Lake Huron.
Sag Bay is main source of P for Lake Huron.
P levels in main body of Lake Huron have dropped (below L Superior).
The food web has effectively collapsed, from bottom up to birds.
Further proposed reductions of P in Saginaw Bay would further reduce amount of P available to Lake Huron.
Deciding on a regulatory P level for Lake Huron will be a complex decision once ANNEX 4 rotates back around to the lake.

Guest editor for JGLR special issue "Managing multiple stressors in Saginaw Bay, 2012.



Based on parallel development of 4 models. GLERL had an active part in one of them.

1986



ES&T
FEATURES

Great Lakes water quality improvement

The strategy of phosphorus discharge control is evaluated

Joseph V. De Pinto
Thomas C. Young
Lyn M. McIlroy
Clarkson University
Potsdam, N.Y. 13676

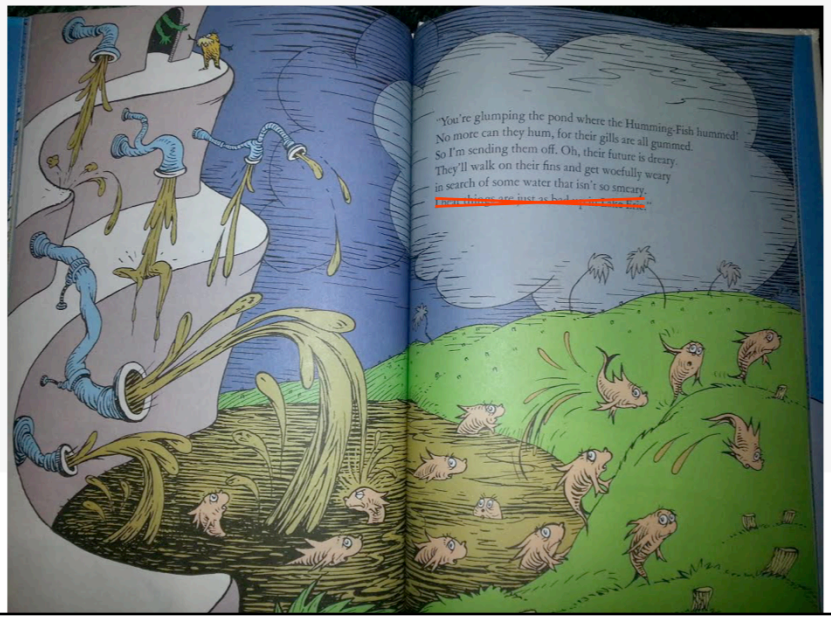
The impressive size of the Great Lakes has not been enough to shield them from many of the water quality problems that have resulted from the tremendous human population explosion within their basin (Table 1). Over the past 180 years the population resid-

quest of either the U.S. or Canadian government, or both. These studies, designed to formulate recommendations to the two governments, are known as "references."

Since its inception the IJC has issued more than 50 references; some of its

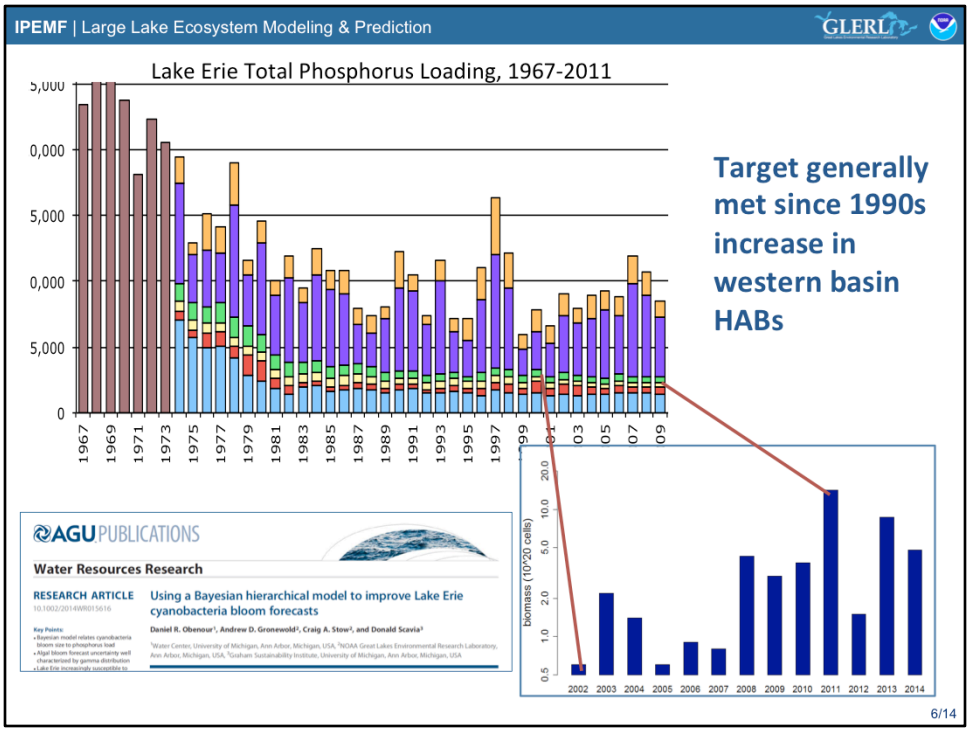
Mission Accomplished !

1986


"You're glumping the pond where the Humming-Fish hummed!
No more can they hum, for their gills are all gummed.
So I'm sending them off. Oh, their future is dreary.
They'll walk on their fins and get woefully weary
in search of some water that isn't so smeary.

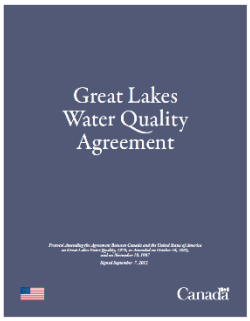
1986

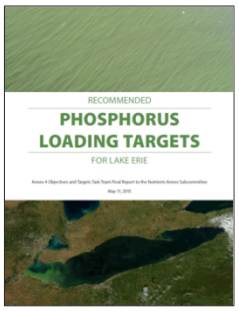

ALGAL BLOOM
ADVISORY
A harmful algal bloom has been detected at this location. Users are encouraged to avoid ingesting water and avoid surface scum.
Image from
8-23-15



Data from Dave Dolan, University of Wisconsin Green Bay

2012 – New GLWQA

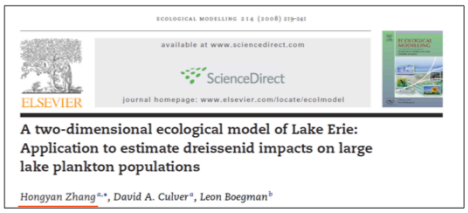




Annex 4 - Nutrients
Six Lake Ecosystem Objectives
Update Substance Objectives (target concentrations)
Update Phosphorus Load Targets
Do this for Lake Erie within 3 years (February 2016)

Annex 4 Subcommittee has been meeting regularly since late 2013
Recommended Phosphorus Loading Targets Report - May 2015
Developed using 9 parallel models

2012 – New GLWQA



ECOLOGICAL MODELLING 214 (2008) 219–241

available at www.sciencedirect.com

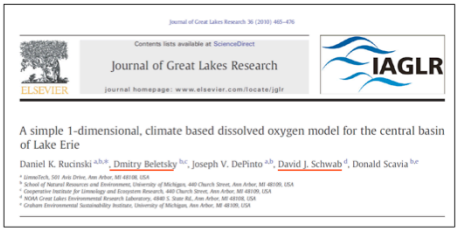
ScienceDirect

journal homepage: www.elsevier.com/locate/ecolmodel

ELSEVIER

A two-dimensional ecological model of Lake Erie: Application to estimate dreissenid impacts on large lake plankton populations

Hongyan Zhang[a,*], *David A. Culver*[a], *Leon Boegman*[b]



Journal of Great Lakes Research 36 (2010) 465–476

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

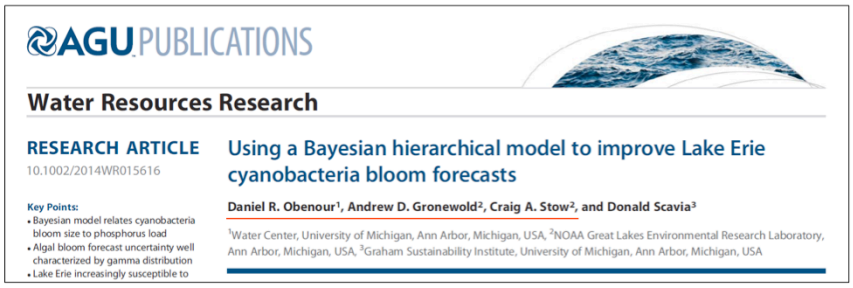
ELSEVIER

IAGLR

A simple 1-dimensional, climate based dissolved oxygen model for the central basin of Lake Erie

Daniel K. Rucinski [a,b,*], Dmitry Beletsky [b,c], Joseph V. DePinto [a,b], David J. Schwab [d], Donald Scavia [b,e]

[a] LimnoTech, 501 Avis Drive, Ann Arbor, MI 48108, USA
[b] School of Natural Resources and Environment, University of Michigan, 440 Church Street, Ann Arbor, MI 48109, USA
[c] Cooperative Institute for Limnology and Ecosystem Research, 440 Church Street, Ann Arbor, MI 48109, USA
[d] NOAA Great Lakes Environmental Research Laboratory, 4840 S. State Rd., Ann Arbor, MI 48108, USA
[e] Graham Environmental Sustainability Institute, University of Michigan, Ann Arbor, MI 48109, USA



AGU PUBLICATIONS

Water Resources Research

RESEARCH ARTICLE

10.1002/2014WR015616

Using a Bayesian hierarchical model to improve Lake Erie cyanobacteria bloom forecasts

Key Points:
- Bayesian model relates cyanobacteria bloom size to phosphorus load
- Algal bloom forecast uncertainty well characterized by gamma distribution
- Lake Erie increasingly susceptible to

Daniel R. Obenour[1], Andrew D. Gronewold[2], Craig A. Stow[2], and Donald Scavia[3]

[1]Water Center, University of Michigan, Ann Arbor, Michigan, USA, [2]NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, USA, [3]Graham Sustainability Institute, University of Michigan, Ann Arbor, Michigan, USA

8/14

Science Advisory Board – review modeling process - December 2014

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

The need for sustained, long-term phosphorus modeling in the Great Lakes

Thus, it would be prudent for the Great Lakes community to invest in a sustained, coordinated modeling effort to carry us into the future.

Ideally this endeavor would include:

- A suite of models of differing complexity and resolution, based on alternative assumptions.
- An ongoing skill assessment of model capabilities.
- Models with the capacity for rigorous uncertainty analysis.
- A home on the internet with documented code and supporting data available to make the process as transparent as possible and allow the community to use and vet the models.
- Regular updating.
- A standing committee to guide development and implementation.
- Support by well-designed monitoring program.

Stow (2015). *JGLR*.

Contents lists available at ScienceDirect

Environmental Modelling & Software

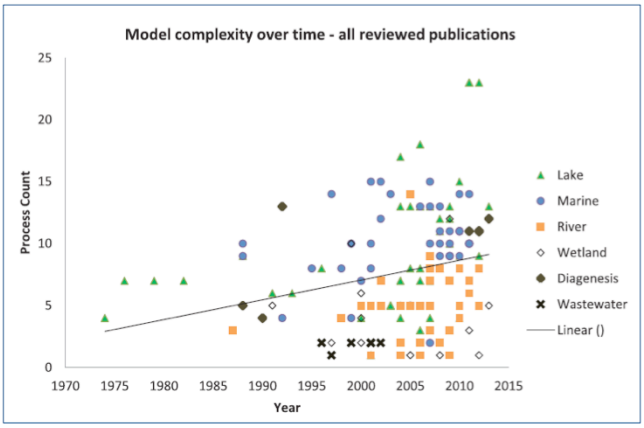
journal homepage: www.elsevier.com/locate/envsoft

State of the art in modelling of phosphorus in aquatic systems: Review, criticisms and commentary☆,☆☆

Barbara J. Robson*

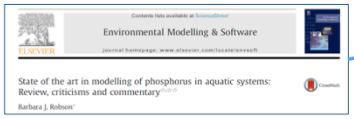
10. How complex should models be?

It is clear that aquatic biogeochemical models are becoming more complex, but there is no clear agreement regarding whether this is appropriate.



- Greater model complexity = greater predictive accuracy?
- Results equivocal
- As a community we are not very good about assessing, reporting accuracy/ reliability

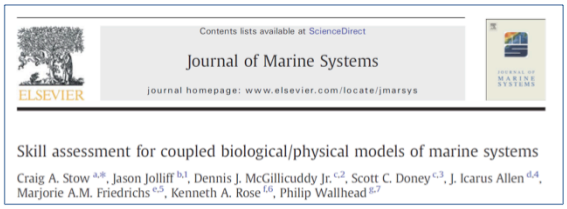
Future Directions


Environmental Modelling & Software

State of the art in modelling of phosphorus in aquatic systems: Review, criticisms and commentary

Barbara J. Robson

This tension between physiological realism and model parsimony can only be resolved by assessing the actual performance of models with different structures.

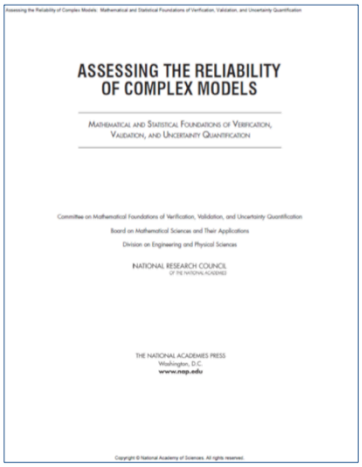

Contents lists available at ScienceDirect

Journal of Marine Systems

journal homepage: www.elsevier.com/locate/jmarsys

Skill assessment for coupled biological/physical models of marine systems

Craig A. Stow [a,*], Jason Jolliff [b,1], Dennis J. McGillicuddy Jr. [c,2], Scott C. Doney [c,3], J. Icarus Allen [d,4], Marjorie A.M. Friedrichs [e,5], Kenneth A. Rose [f,6], Philip Wallhead [g,7]


ASSESSING THE RELIABILITY OF COMPLEX MODELS

Mathematical and Statistical Foundations of Verification, Validation, and Uncertainty Quantification

Committee on Mathematical Foundations of Verification, Validation, and Uncertainty Quantification

Board on Mathematical Sciences and Their Applications

Division on Engineering and Physical Sciences

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Develop, test models of differing complexity, evaluate relative performance

It is not appropriate to ask whether a model is right or wrong.

Instead we should ask:

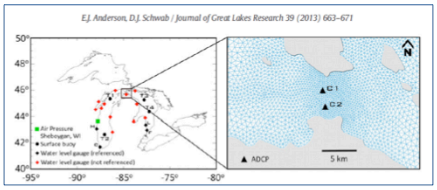
What is its domain of utility?

GLERL has expertise in fine-scale, simulation modeling:

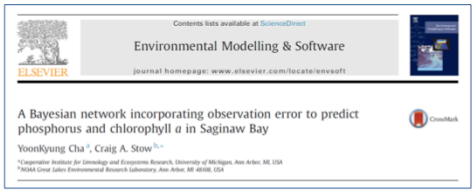

Journal of Great Lakes Research

Predicting the oscillating bi-directional exchange flow in the Straits of Mackinac

Eric J. Anderson, David J. Schwab



and contemporary, probabilistic approaches:


Environmental Modelling & Software

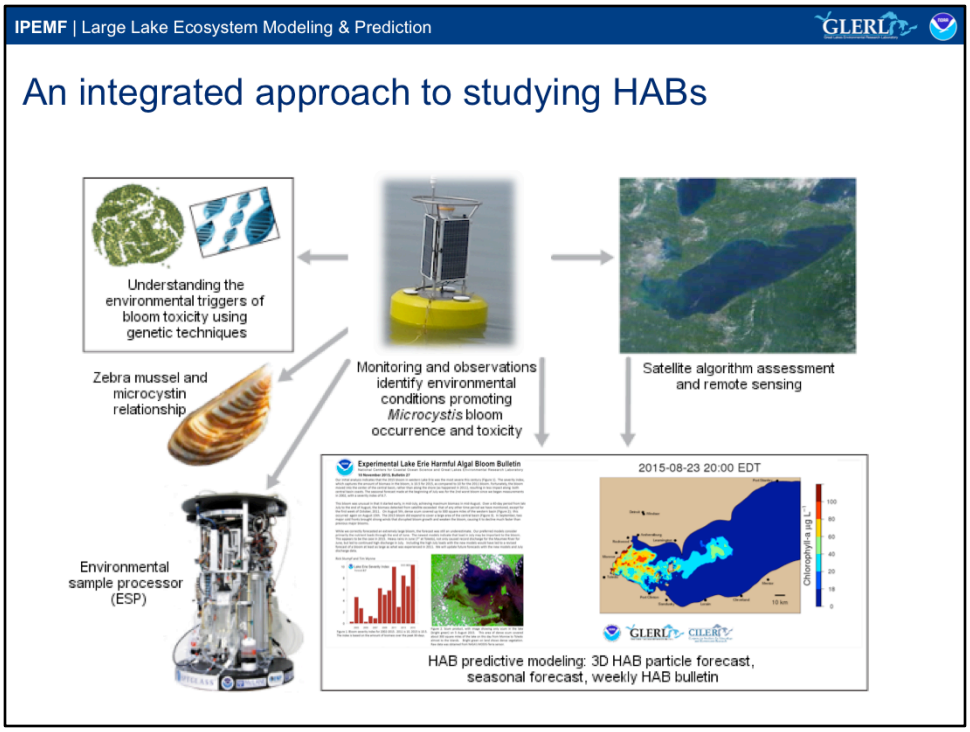
A Bayesian network incorporating observation error to predict phosphorus and chlorophyll *a* in Saginaw Bay

YoonKyung Cha, Craig A. Stow

$$L(z_k, y_k, x_i|\boldsymbol{\theta}) = \prod_{k=1}^{l} \frac{1}{(2\pi\sigma_z^2)^{\frac{1}{2}}} e^{\frac{(z_k - x_k)^2}{2\sigma_z^2}} \prod_{k=1}^{m} \frac{1}{(2\pi\sigma_y^2)^{\frac{1}{2}}} e^{\frac{(y_k - x_k)^2}{2\sigma_y^2}} \prod_{i=1}^{n} \frac{1}{(2\pi\sigma_x^2)^{\frac{1}{2}}} e^{\frac{(x_i - x_k)^2}{2\sigma_x^2}}$$

$$\prod_{j=1}^{J} \frac{1}{(2\pi\sigma_{zo}^2)^{\frac{1}{2}}} e^{-\frac{(z_{kj} - x_{k\,prior} - x_{k\,prior}\,mean(y_j - x_{k\,prior}))^2}{2\sigma_{zo}^2}} \frac{1}{(2\pi\sigma_{yo}^2)^{\frac{1}{2}}} e^{-\frac{(y_{kj} - x_{k\,prior} - x_{k\,prior}\,mean(y_j - x_{k\,prior}))^2}{2\sigma_{yo}^2}} \frac{1}{(2\pi\sigma_{xo}^2)^{\frac{1}{2}}} e^{-\frac{(x_{kj} - x)^2}{2\sigma^2}}$$

- Clear implications for developing models for transition to operations
- Draws on strengths (Modeling, Observations, Process Research)
- Supports our HABs program
- Serve a long-term need in the Great Lakes community
- Partners Essential – Federal, State, Provincial Agencies, Academia



Overarching research statement:
Understanding the drivers of bloom ecology will aid in enhancing predictive models that forecast bloom size, location AND toxicity

Phosphorus

Thank You
Questions?